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ABSTRACT

The Federal Communications Commission (FCC) assigns segments of the radio spectrum to categories of users, and specific frequencies within each segment to individual users. Since demand for channel space exceeds supply, the process is complex. The radio spectrum can be compared to a long ruler: the portion from 10-540 kiloHertz has been set aside for long-range radiotelegraph; from 535-1605 kiloHertz is for AM broadcasts; from 1605 kiloHertz to 25 magaHertz is for long-distance and international communications, ships at sea and aircraft in flight; from 25-890 megaHertz is for AM radio and TV; 890 megaHertz to 40 gigaHertz is for other specialized services, and above 40 gigaHertz is used for experimental work. Not all broadcasters require the same amount of radio spectrum. An FM station requires 20 times the channel space of an AM station. A TV signal uses 600 times more space than an AM station. Some increased use of channels is obtained by fequency sharing or "pooling". Some new users could be squeezed into the radio spectrum with more efficiency and cooperative effort by current users. (MG)

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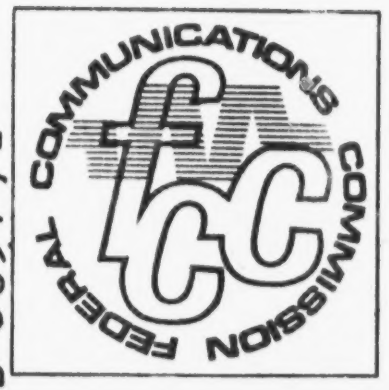

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Frequency Allocation

INFORMATION BULLETIN

THE RADIO SPECTRUM

Allocation of radio frequencies involves setting aside segments of the radio spectrum for the use of particular radio services and assigning specific frequencies within those segments for the operation of individual radio stations. This is a fundamental task of the FCC which is also responsible for establishing the rules and regulations which govern the operation of these stations.

In some respects, frequency allocation can be likened to building highways. The planning and development of invisible communication lanes, however, is much more complicated than road building. There is still a wide choice of land highway routes but radio paths are limited in number and many are very crowded. And, unlike land traffic, radio transmissions cannot be routed by underpasses and overpasses. Neither can they obey traffic signals to allow other traffic to pass, or to stop at any given point, for radio waves spread out in all directions, crossing state lines and international boundaries.

As land traffic increases, highways are widened and alternate routes provided when necessary. Radio highways too can handle only a certain amount of traffic or transmissions before additional lanes are needed and more exacting operating controls employed.

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RADIO PATHS DIFFER

Not all radio paths are the same width. Some types of transmissions require wider lanes than others. For example, an FM broadcast needs a channel 20 times wider than that used by an AM station, while a TV station's combination of picture and sound requires about 600 times the spectrum space occupied by an AM program. In the nonbroadcast field, too, channel widths differ according to the nature and requirements of the particular services.

Furthermore, not all radio frequencies behave alike. Those in various portions of the spectrum have different characteristics. For example, 1000 kiloHertz is suitable for AM broadcasting but not for FM or TV broadcasting. Similarly, 410 kiloHertz is good for ship navigation by direction finding but not for ship navigation by radar. Consequently, the particular qualities of each radio band must be considered in determining the type of service which can best operate on it. Use of frequency bands, especially in the upper reaches of the radio spectrum, is further determined by the development, cost and availability of apparatus suitable for operation in those areas.

Also, there are certain limitations in any radio system which govern its use. It goes without saying that most mobile and portable transmitters require frequencies which provide limited range. On the other hand, transmissions which cross the seas need frequencies with long-range characteristics while satellite communications have still different requirements.

There are also many frequencies which bear heavy traffic in some areas but go begging elsewhere. Means must be found to put these fallow radio lanes to work without disruption to existing services, and without causing interference.

Any extensive rerouting of traffic over the invisible radio paths requires complex planning and execution. A mass of facts and figures relating to the use of the radio spectrum must be studied, plotted and applied. In some respects the work resembles a giant checkerboard. For example, changing the frequency of one station may mean moving it to another band, and moving one in that band to still another, and so on until a chain reaction of shifts is completed in order to accommodate the first move without inviting interference problems.

RADIO BANDS, CHANNELS AND FREQUENCIES

It is customary to speak of the spectrum space occupied by each radio service as a "band", meaning a group of contiguous channels allocated for the use of a particular service. These channels are the traffic lanes assigned for the transmissions of individual stations in that service.

Within these channels each station operates on a designated "frequency". This means that it transmits its electrical impulses at so many "cycles" (electrical vibrations called "waves") a second, or "Hertz". These emissions are measured in "kiloHertz", "megaHertz",

"gigaHertz" and "teraHertz". A kiloHertz is a short way of denoting a thousand of these waves a second, a megaHertz indicates a thousand kiloHertz, a gigaHertz means a thousand megaHertz and a teraHertz is a thousand gigaHertz. Radio waves of certain frequencies travel great distances, others have shorter range.

The lowest frequency normally used for radio communication is 10,000 Hertz (10 kiloHertz). This is considered to be the bottom of the radio spectrum. It encompasses that part of the electromagnetic spectrum which can be used for communication purposes. It is arranged progressively according to the respective wave lengths graduating upwards from "long waves" and "short waves", to microwaves (above about 300 megaHertz).

In the early days of radio it was customary to refer to a station operating on a certain "wave length". As use of the radio spectrum expanded, however, it became simpler to use the "frequency" designation, which is now national and international practice.

For convenience, the radio spectrum below 30 kiloHertz is known as the VLF (Very Low Frequency) range; from 30 to 300 kiloHertz, LF (Low Frequency); from 300 kiloHertz to 3 megaHertz, MF (Medium Frequency); 3 to 30 megaHertz, HF (High Frequency); 30 to 300 megaHertz, VHF (Very High Frequency); 300 to 3000 megaHertz, UHF (Ultra High Frequency); 3 to 30 gigaHertz, SHF (Super High Frequency); and 30 to 300 gigaHertz, EHF (Extremely High Frequency).

HOW THE RADIO SPECTRUM IS ORGANIZED

Before World War II, the usable portion of the radio spectrum was limited to between 10 kiloHertz and 300 megaHertz. Subsequent electronic developments made it possible to extend the useful spectrum to 40 gigaHertz.

For demonstration purposes, the radio spectrum may be compared to a long vertical ruler with inches or fractions of inches marking off, but in irregular bands allocated to the different radio services.

That portion between 10 and 540 kiloHertz is employed largely by long range radiotelegraph stations and radio beacons for ships and aircraft.

The section between 535 and 1605 kiloHertz is the familiar AM ("standard") broadcast band.

Between 1605 kiloHertz and 25 megaHertz are bands for long-distance radiotelegraph and radiotelephone communication, for ships at sea and planes in the air, and for international broadcasting.

FM and TV broadcast, as well as various safety and special services, are individually provided for in the segment between 25 and 890 megaHertz.

Above that, extending to 40 gigaHertz, are bands for radio navigation, common carrier, mobile, and a host of other specialized radio services.

Spectrum space beyond 40 gigaHertz is employed mainly for experimental and developmental work in connection with prospective new or improved radio services and equipment. Experimentation also is being carried out on frequencies within the visible light spectrum, potentially extending the upper limit of the electromagnetic spectrum used for communication.

It is difficult to portray an exact spectrum chart because various services -- such as Government, amateur, and others -- have scattered allocations and many bands must be shared by different services.

It is interesting to note that the space occupied by AM broadcasting is only one forty-thousandth of the entire radio spectrum currently allocated to the various services. In addition to bands for AM, FM and TV broadcast, there are bands for aviation, marine, police, fire, industrial, land transportation, amateur, citizens, common carrier and other uses. Also, there are portions of the radio spectrum set aside for noncommunication equipment -- such as medical, industrial and other electronic devices -- so that their excess energy can be released without causing interference to radio channels used for communication purposes.

ALLOCATION CONSIDERATIONS

It would be wasteful and chaotic to operate a broadcast station on one frequency and, say, a police station and a ship station on adjacent frequencies. There must be appropriate bands of frequencies for the some 67 different radio services which the Federal Communications Commission now accommodates, and within these bands assignments must be made for the operation of some 7 million fixed and mobile transmitters.

In the early days or radio, a few kiloHertz one way or another were of little importance. Later, with increasing use of the spectrum, the problem of interference between stations grew proportionately, and it became necessary to define more precise channel boundaries, engineering standards, and other requirements.

Since maximum utilization of the radio spectrum depends upon optimum allocation of frequency bands and upon proper use of the assigned channels, the Commission is required to study the behavior of radio waves, to test apparatus and performance, and to monitor the technical quality of signals.

RADIO CHANNEL SHORTAGE

The primary obstacle to expanded radio use is the scarcity or nonavailability of channels for certain fast-growing services, particularly in the nonbroadcast field, such as land mobile radio. Technical developments have made it possible to move further "upstairs" in spectrum occupancy but, at the same time, the number of industrial and business firms desiring to employ radio has expanded even more rapidly. The result is that there is a dearth of frequencies for certain new or expanding services.

In consequence, some frequency rationing is required in order to provide the maximum benefit to the greatest number of people. Basically, preference in the use of radio is given those services on which the safety of life and property depends.

Some increased use of nonbroadcast radio channels in short supply is obtained by increasing the amount of frequency sharing or "pooling" in an area. Further relief is obtained through utilization of so-called "split channel", "single sideband", and other technical refinements. Splitting channels and, in some cases, using single sideband permits more stations to operate in a given band. A higher degree of efficiency in the use of all frequencies, as well as cooperative effort, is required to open the door to new groups as well as to take care of mushrooming existing services.

INTERNATIONAL RADIO AGREEMENTS

Interference can come not only from domestic radio stations and the increasing number of electronic devices but also from foreign radio stations. That is why bilateral and multilateral radio arrangements between nations are necessary.

Bands allocated for radiotelephone and radiotelegraph must be used by such stations of all nations, and the ship, aeronautical, and broadcast bands must also be shared. A French plane over New York must be able to talk to the local airfield on the same frequency that an American plane over Paris uses to communicate with the airfield there. By the same token, merchant ships the world over must be able to communicate on frequencies common to marine use.

The international aspect of radio has developed to such an extent that almost no major frequency allocation can be made without considering worldwide usage. In consequence, the primary allocation of frequency bands is now determined by international treaty and other agreement, and assignment of individual channels within those bands is made by the member nations. This now includes frequencies for space communication.

FREQUENCY CHARTS AND LISTS

The Federal Communications Commission does not issue a frequency chart, but frequency allocations by services (not individual stations) are listed in Part 2 of Volume 2 of its rules which may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.